Excretory Products of *Tegula funebralis* and *Tegula brunnea*

(Mollusca : Gastropoda)

BY

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(1 Table)

INTRODUCTION

Questions concerning the excretory products of *Tegula funebralis* (A. Adams, 1854) arose when some rather casual qualitative tests were performed on the kidneys of the snail. The right kidney appeared to contain a high concentration of uric acid while the left kidney had none. This is a quantitative study of the excretory products of this snail and the related species, *T. brunnea* (Philippi, 1848).

METHODS

The snails, both *Tegula funebralis* and *Tegula brunnea,* used in these experiments were taken from the same area near the Hopkins Marine Station in Pacific Grove, California. They were collected at low tide; all except two groups were immediately killed and the tissues to be investigated were prepared as protein-free filtrates. Two groups were kept in a tank in the laboratory for a week before they were examined; they were not fed during this period. The *Tegula funebralis* used were approximately 2 - 2.5 cm. in diameter. The *Tegula brunnea* were slightly smaller, 1.8 - 2.0 cm. in diameter. It was necessary to use large snails in order to obtain samples free of other contaminating tissues. A few *Tegula montereyi* (Kiener, 1850), 2.5 - 3.0 cm. in diameter, were used; these came from kelp beds forty feet under surface.

The tissues examined were the etenidium, digestive gland, and the two kidneys. The latter (which could be more accurately called coelomoducts) are very different morphologically. The left kidney is known as the papillary sac because of the many villi on its internal surface. Each villus has a hemocoelic space in its center. The right kidney has two lobes; the anterior one runs parallel to the left kidney, and the posterior one is behind the pericardial cavity. The left kidney is white; in both *Tegula funebralis* and *Tegula brunnea* the right kidney is green in males and yellow in females. The posterior lobe of the right kidney was used since it could be more readily dissected free of other tissue.

All four tissues from each group of ten snails were removed, blotted on a piece of filter paper, and weighed on a Mettler balance. A tungstic acid filtrate prepared by Haden's modification of Folin's method (Todd, Sanford & Stilwell, 1948, p. 352) was used to remove protein from a tissue homogenate. The four filtrates from the tissues of each group were stored between tests in a freezer.

In order to interpret the results of the tests for excretory products, it was necessary to determine the total non-protein nitrogen in the various tissues. This was done by the method of Folin and Wu (Todd, Sanford & Stilwell, 1948, pp. 353-354) which was modified by decreasing all the constituents in proportion so that the final volume after the addition of Nessler's solution would be 10 ml.

Ammonia was determined by adding 1 ml of Nessler's solution to a solution of 1 ml of protein-free filtrate and 8 ml. of distilled water. Urea was determined by the modified method of Hawk-Andes (Levinson & MacFate, 1952, pp. 370-371); the volume of all the reagents was reduced proportionally to give a final volume after Nesslerization of 10 ml. Twelve drops of a five per cent urease solution made from Arlington tablets and purified with permutit powder were used. Benedict's method for the quantitative determination of uric acid (Todd, Sanford & Stilwell, 1948, pp. 361-362) was used without modification.

RESULTS

Uric acid was found in significant quantities in the right kidneys of both *Tegula funebralis* and *Tegula brunnea,* but no trace of this compound was found in the left kidneys of these snails. In *Tegula montereyi* there was no detectable uric acid present in any of the tissues tested. Slight traces of free ammonia were found in the digestive

Table 1

Group	Tissue	Non-protein N mg/g wet wt.	Uric acid mg/g wet wt.	Uric acid N / Non-protein N × 100
Tegula funebralis				
1[1]	Right kidney	3.58	1.27	11.8
	Left kidney	0.907	0	
	Digestive gland	1.55	0	
	Ctenidium	0.796	0	
2	Right kidney	1.55	1.89	40.7
	Left kidney	1.66	0	
	Digestive gland	2.81	0	
	Ctenidium	1.70	0	
3	Right kidney	1.86	1.36	24.4
	Left kidney	1.54	0	
	Digestive gland	1.00	0	
	Ctenidium	1.45	0	
Tegula brunnea				
1[1]	Right kidney	6.86	4.0	22
	Left kidney	1.79	0	
	Digestive gland	2.15	0	
	Ctenidium	1.73	0	
2	Right kidney	4.82	5.03	34.8
	Left kidney	3.08	0	
	Digestive gland	2.66	0	
	Ctenidium	2.98	0	
3	Right kidney	2.20	4.48	76.6
	Left kidney	2.50	0	
	Digestive gland	1.80	0	
	Ctenidium	3.06	0	

[1] maintained in the laboratory for one week without added food.

gland of both *Tegula funebralis* and *Tegula brunnea*. There was no detectable urea in any of the tissues examined. These results are presented in Table I.

DISCUSSION

A comparison of the uric acid production of *Tegula funebralis* and *T. brunnea* with that of *T. montereyi* seems to support Needham's theory concerning the adaptive significance of uric acid formation (Needham, 1935). Since *T. montereyi* are constantly in the water, any ammonia formed can be continuously diffused into the sea, and so there is no need for them to expend the extra energy necessary to convert their wastes into uric acid. *Tegula funebralis* and *T. brunnea,* which both live in the intertidal zone,are exposed to the air a good deal of the time and so tend to convert their wastes into the non-toxic and conveniently stored uric acid.

The left kidney does not appear to have any excretory function and perhaps serves as an organ of reabsorption as does the left kidney of *Haliotis* (Harrison, 1961). Reabsorption would enable the animal to conserve many valuable nutrients that would otherwise be lost in the urine. This function of the left kidney seems quite probable when one considers both the increase in surface area

provided by the papillae and the highly vascularized nature of these papillae.

SUMMARY

1. Tests were performed on the snails, *Tegula funebralis* and *T. brunnea,* to determine the nature and quantity of their excretory products and the organs of excretion.

2. Standard colorimetric assays were used on homogenates prepared from the ctenidium, digestive gland, right and left kidneys. Total non-protein nitrogen, ammonia, urea, and uric acid were determined.

3. Uric acid was observed to be the major excretory product of these snails. It accounted for 11.8% to 76.6% of the total non-protein nitrogen in the right kidneys, the only organs where this waste product was detectable. Only slight traces of ammonia were found in the digestive gland, and no urea was present in the tissues tested.

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The Distribution and Movement of *Tegula funebralis* in the Intertidal Region of Monterey Bay, California

(Mollusca : Gastropoda)

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(9 Text figures)

INTRODUCTION

Tegula funebralis (A. ADAMS, 1854) is very common along the west coast of California, although little work has been done on its intertidal distribution. Hewatt (1934) describes its distribution as between the plus one and plus five foot level above mean lower low water. Ricketts and Calvin (1962, pp. 352-355) put the population center at the three foot tide level. Neither reference describes the distribution extent along the intertidal region. We investigated *Tegula funebralis*' intertidal distribution and movement patterns in relation to certain biological and physical environmental factors. Before investigating movement patterns, we wanted an accurate, correlatable distribution analysis for several areas along Mussel Point, Pacific Grove, California. To do this, we collected information pertaining to numbers and size classes of this snail along with environmental data of the areas, such as vertical level of collection, algal covering, area configuration, substratum, and wave and current action. Factors that seem to